Observations were made on the pumping of the oyster and it appears that glucose under the conditions of this experiment will stimulate the oyster to pump. Oysters that were not fed were very rarely observed with shells agape.

## SUMMARY AND CONCLUSIONS

Two experiments were conducted to investigate the use of glucose in the nutrition of the oyster. Comparisons were made on the concentration and removal of glucose from tanks with and without oysters; and a study was also made to compare the longevity of oysters starved with the length of life of oysters being fed glucose. The concentration of glucose in the water was maintained within a range of 5 to 15 mg per liter.

Under the conditions of these experiments, it was found that more glucose was needed to maintain the concentration in the tank containing oysters than in tanks without oysters. Also, evidence was developed to show that about 19.5 per cent of the glucose removed from the tank was utilized by the oyster; however, these data do not necessarily indicate direct assimilation. The oysters being fed glucose lived an average of 68.2 days longer than those which were starved. It was observed that when maintained in open tanks and in artificial sea water that oysters are capable, in some instances, of living longer than one year and three weeks without being fed.

More investigations are needed to ascertain whether oysters can directly utilize glucose or other soluble carbohydrates. Studies are also needed to determine if soluble carbohydrates can be fed as a supplement for growth with other nutrients or in natural nonfiltered bay water. We are encouraged to pursue these experiments by the findings of Stephens (1961, 1962, 1963, 1964), whose work showed the uptake of labelled glucose and amino acids by several marine invertebrates.

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# NOTES ON POSTLARVAE OF *PANULIRUS ARGUS*

Ross Witham, Robert M. Ingle, and Harold W. Sims, Jr.

In June of 1963 a random push net sample taken in the Indian River adjacent to the dock of the House of Refuge Museum near Stuart, Florida, produced several postlarval specimens of the spiny lobster *Panulirus argus* (Latr.). The existence of adult populations of *P. argus* in the offshore waters of the Martin County area has been reported by Moore (1962) and Robinson and Dimitriou (1963). To our knowledge this is the first report of postlarval spiny lobster in this area.

Literature on the ecology of the early postlarval stages of *Panulirus argus* is nonexistent and the study of the growth rate is limited to the work of Lewis et al. (1952). The lack of data on this phase of lobster research and the established availability of postlarvae in the Stuart area led us to begin this study. Postlarvae were collected at random in the waters of the Indian River, the Intracoastal Waterway south of the St. Lucie Inlet, and in the waters of Hobe Sound. This report provides preliminary data obtained during the first year of work.

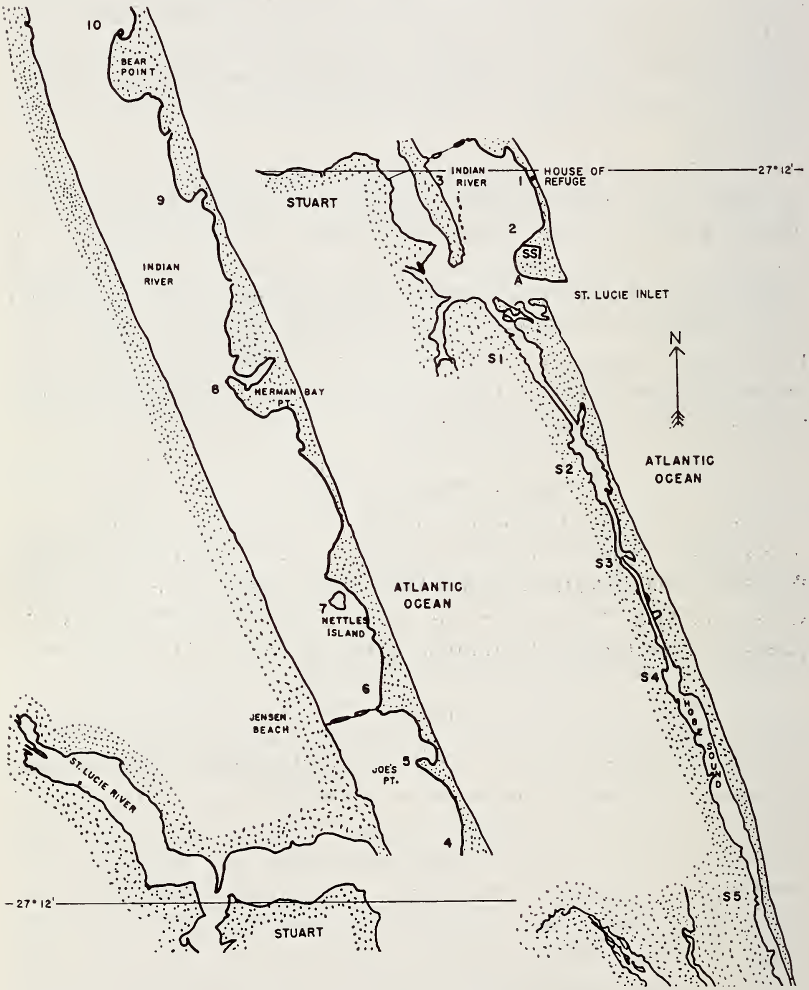
## Methods and Materials

Samples were taken using a variation of the push net commonly used in the collection of invertebrates in grass flats. The frame of the net was made in the form of a 3 ft by 3 ft square using one inch Polyvinyl chloride tube. The bag of the net was built as a shallow pocket formed of fiberglass screen.

The method of collecting varied with the substrate. In mangroves (*Rhizophora* sp.) the net was placed under a mass of algae or other organisms growing on the submerged roots; with the net in place, the attached organisms were pulled from the roots and allowed to fall into the bag. On grass flats the net was inserted under a mass of unattached plants and lifted; the algae thus collected were examined for postlarvae. On seawalls, piling, and rock, where the sessile plants could not be removed by the former methods, a ⅓ meter plankton net was fastened to an 8 foot pole, with a metal scraper attached above the net; this scraped the growths from the solid submerged object, with the sample falling in the plankton net. In rocky areas two small screen nets were used;

the sample was gripped between the nets, pulled loose, and brought to the surface for examination.

Some of the postlarvae were taken to the laboratory for feeding and growth observations. Others were preserved in 10 per cent formaldehyde.




Map 1. Collecting stations near Stuart, Florida.

## GENERAL DESCRIPTION OF THE AREA

The inland waters of this area can best be described as two shallow lagoons formed by offshore barrier islands (Map 1). They are connected by the Intracoastal Waterway, although historically a shallow, tortuous meander joined them. The water depth, except in the channels, is relatively shallow, most of the areas being less than a fathom at low tide. Dense beds of *Syringodium* and *Diplanthera* are common throughout the area except in the Intracoastal Waterway and in Hobe Sound, where they are very sparse (Phillips and Ingle, 1960).

Marine organisms, principally plants, found throughout the area in which the postlarvae were found, varied in density throughout the year. Included were such species as *Bugula* sp., *Giffordia mitchellae* (Harv.), *Gracilaris cylindrica* (Børgs.), *Acanthophora spicifera* (Vahl.), *Hypnea cervicornis* (J. Ag.), *Hypnea cornuta* (Lamx.), *Erythrotrichia carnea* (Dillw.), *Ceramium brevizonatum* H. E. Peterson, and *Acroochaetium sargassii* (Børgs.). These were listed by Phillips (personal communication) and were found attached or unattached. Stations 1 and 3-10 are located in typical shallow grass beds with mangrove-lined shores. Station 2, located at Seminole Shores Marina (S. S. on chart), has seawalls, pilings, rocks, and some small grass flats.

Station A is located on the mangrove shore line bordering the north side of the St. Lucie Inlet. Stations S1-S5 are situated in the Intracoastal Waterway and Hobe Sound area. The 16 stations shown on Map 1 were sampled at random during the 13 month period of this study. Station data obtained are provided in Table 1.

## RESULTS

Our data indicate that the transparent puerulus stage begins to appear in small numbers during the months of January and May and becomes increasingly common throughout the summer and fall, the peak number being reached during October and November. These findings do not coincide with those of Lewis et al. (1952), who worked in the Miami area and found January to be the most productive for this stage. No explanation is offered at this time for this discrepancy. A comparison of January water temperatures for the two bays would possibly provide a clue.

TABLE 1

Post-larvae station data for *Panulirus argus*

| Station No. | Date | Total Captured | Transparent No. | Transparent Size (mm) | Semitransparent No. | Semitransparent Size (mm) | Pigmented No. | Pigmented Size (mm) | Salinity (ppt) | Temp. (C) | Turbidity (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6-18-63 | * | * | * | * | * | * | 30-35 | * | * | * |
| 1 | 6-27-63 | 2 | 2 | 15-17 | 0 | — | 0 | — | * | * | * |
| 1 | 7-2-63 | 3 | 1 | 17 | 0 | — | 2 | 34-39 | * | * | * |
| 1 | 7-16-63 | 7 | 1 | 15 | 1 | 20 | 5 | 33-50 | * | * | * |
| 3 | 8-15-63 | 3 | 1 | 15 | 1 | 17 | 1 | 30 | * | * | * |
| 1 | 8-20-63 | 13 | 9 | 15 | 3 | 15 | 1 | 17 | * | * | * |
| 2 | 8-22-63 | 20 | 3 | 15 | 16 | 15 | 1 | 40 | * | * | * |
| 1 | 9-12-63 | 2 | 0 | — | 0 | — | 2 | 53-67 | * | * | * |
| 1 | 9-20-63 | 1 | * | * | * | * | * | * | * | * | * |
| 1 | 9-26-63 | 1 | 1 | 16 | 0 | — | 0 | — | * | * | * |
| 1 | 10-4-63 | 2 | 0 | — | 0 | — | 2 | 19-25 | 26.0 | * | * |
| 1 | 10-17-63 | 11 | 10 | 15 | 1 | 15 | 0 | — | 31.4 | 24.4 | 2.0 |
| 1 | 10-22-63 | 56 | 9 | 15 | 26 | 15 | 21 | 15-41 | 33.5 | 23.3 | 3.0 |
| 1 | 11-6-63 | 17 | * | * | * | * | * | * | 33.5 | 21.0 | 2.5 |
| 1 | 11-12-63 | 29 | 27 | * | 0 | — | 2 | * | 34.5 | 23.5 | 4.0 |
| 1 | 11-21-63 | 57 | 41 | 15.5-16.5 | 16 | 17 | 0 | — | 35.0 | 21.0 | 3.0 |
| 1 | 12-5-63 | 6 | 0 | — | 1 | 16.5 | 5 | 17.5-19.5 | 37.0 | 18.0 | 4.0 |
| 1 | 12-7-63 | 12 | 1 | * | 11 | * | 0 | — | 36.5 | 18.0 | 4.0 |
| 1 | 12-17-63 | 13 | 5 | 16-18 | 5 | 16-18 | 3 | 18-23.5 | 33.4 | 17.0 | 4.0 |
| 1 | 12-21-63 | 3 | 2 | 16.5 | 0 | — | 1 | 21.5 | 32.8 | 15.0 | 4.0 |
| 5 | 1-7-64 | 0 | — | — | — | — | — | — | 27.0 | 21.0 | 3.0 |
| 1 | 1-7-64 | 2 | 0 | — | 1 | 16.5 | 1 | 22 | 27.0 | 21.0 | 2.0 |
| 2 | 1-9-64 | 0 | — | — | — | — | — | — | 36.0 | 23.0 | 3.0 |

TABLE 1 (cont.)

Post-larvae station data for *Panulirus argus*

| Station | | Total | Transparent | | Semitransparent | | Pigmented | | Salinity | Temp. | Turbidity |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Date | Captured | No. | Size (mm) | No. | Size (mm) | No. | Size (mm) | (ppt) | (C) | (ft) |
| 1 | 1-21-64 | 1 | 1 | 17 | 0 | — | 0 | — | 31.5 | 20.0 | 3.5 |
| 4 | 1-30-64 | 0 | — | — | — | — | — | — | 32.0 | 18.0 | 4.0 |
| 3 | 1-30-64 | 0 | — | — | — | — | — | — | 30.5 | 17.0 | 3.0 |
| 1 | 2-13-64 | 0 | — | — | — | — | — | — | 32.6 | 19.0 | 4.0 |
| 1 | 2-27-64 | 0 | — | — | — | — | — | — | 37.5 | 20.0 | 4.0 |
| 1 | 3-5-64 | 0 | — | — | — | — | — | — | 38.5 | 23.0 | 1.5 |
| 1 | 3-24-64 | 1 | 0 | — | 1 | 16 | 0 | — | 38.0 | 22.0 | 4.0 |
| 1 | 4-2-64 | 3 | 0 | — | 0 | — | 3 | 19 | 38.2 | 22.0 | 3.0 |
| 1 | 4-16-64 | 5 | 0 | — | 3 | 18 | 2 | 19 | 38.3 | 27.0 | 3.5 |
| 1 | 4-21-64 | 11 | 0 | — | 0 | — | 11 | 16-19 | 38.5 | 28.0 | 3.0 |
| 2 | 4-23-64 | 3 | 0 | — | 0 | — | 3 | 17 | 37.5 | 27.0 | 3.5 |
| 5 | 4-30-64 | 0 | — | — | — | — | — | — | 35.5 | 28.0 | 1.5 |
| 6 | 4-30-64 | 0 | — | — | — | — | — | — | 34.5 | 28.0 | 3.5 |
| 1 | 5-5-64 | 1 | 0 | — | 0 | — | 1 | 17 | 35.4 | 23.5 | 3.5 |
| 1 | 5-12-64 | 4 | 1 | 16 | 0 | — | 3 | 26 | 36.0 | 27.5 | 3.5 |
| 1 | 5-19-64 | 4 | 0 | — | 4 | 16-17 | 0 | — | 36.0 | 26.0 | 3.0 |
| 1 | 5-26-64 | 0 | — | — | — | — | — | — | 36.6 | 28.0 | 3.5 |
| 2 | 6-2-64 | 0 | — | — | — | — | — | — | 37.2 | 27.5 | 5.5 |
| 1 | 6-2-64 | 7 | 1 | 18 | 0 | — | 6 | 22-34 | 36.5 | 28.0 | 4.5 |
| 3 | 6-2-64 | 0 | — | — | — | — | — | — | 34.5 | 28.0 | 3.0 |
| 5 | 6-4-64 | 0 | — | — | — | — | — | — | 35.5 | 28.0 | 3.0 |
| 6 | 6-4-64 | 0 | — | — | — | — | — | — | 34.6 | 27.0 | 3.5 |
| 7 | 6-4-64 | 0 | — | — | — | — | — | — | 34.6 | 27.0 | 2.5 |

TABLE 1 (cont.)

Post-larvae station data for *Panulirus argus*

| Station | | Total | Transparent | | Semitransparent | | Pigmented | | Salinity | Temp. | Turbidity |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Date | Captured | No. | Size (mm) | No. | Size (mm) | No. | Size (mm) | (ppt) | (C) | (ft) |
| 4 | 6-4-64 | 5 | 0 | — | 1 | 17 | 4 | 17-45 | 34.5 | 27.0 | 3.0 |
| S1 | 6-9-64 | 1 | 0 | — | 1 | 17 | 0 | — | 32.0 | 30.0 | 3.5 |
| S2 | 6-9-64 | 8 | 0 | — | 4 | 17-18 | 4 | 20 | 32.0 | 30.0 | 3.0 |
| S3 | 6-11-64 | 0 | — | — | — | — | — | — | 33.5 | 30.0 | 5.0 |
| S4 | 6-11-64 | 2 | 0 | — | 1 | 16 | 1 | 18 | 35.6 | 30.0 | 5.0 |
| S5 | 6-11-64 | 5 | 0 | — | 4 | 16.5-18 | 1 | 20 | 36.5 | 30.0 | 5.5 |
| 1 | 6-19-64 | 5 | 0 | — | 0 | — | 5 | 16.5-43 | 37.5 | 27.5 | 4.0 |
| 2 | 6-19-64 | 1 | 0 | — | 1 | 17 | 0 | — | 38.5 | 25.0 | 5.0 |
| 8 | 6-23-64 | 0 | — | — | — | — | — | — | 38.0 | 30.5 | 4.5 |
| 9 | 6-23-64 | 0 | — | — | — | — | — | — | 37.6 | 32.0 | 4.5 |
| 10 | 6-23-64 | 0 | — | — | — | — | — | — | 38.2 | 31.0 | 4.5 |
| 2 | 6-30-64 | 0 | — | — | — | — | — | — | 36.3 | 27.0 | 6.0 |
| 1 | 6-30-64 | 17 | 0 | — | 0 | — | 17 | 19-45 | 36.3 | 29.0 | 3.0 |
| 4 | 6-30-64 | 8 | 0 | — | 0 | — | 8 | 19-38 | 35.5 | 30.0 | 3.0 |
| 5 | 6-30-64 | 0 | — | — | — | — | — | — | 36.3 | 32.0 | 2.5 |
| S1 | 7-7-64 | 3 | 0 | — | 2 | 16.5-19.5 | 1 | 17 | 34.5 | 30.0 | 2.5 |
| S2 | 7-7-64 | 5 | 1 | 18 | 2 | 17-19 | 2 | 24.5-28 | 36.6 | 31.0 | 4.0 |
| 7 | 7-21-64 | 2 | 0 | — | 0 | — | 2 | 55-61 | 33.5 | 31.0 | 4.0 |
| A | 7-21-64 | 4 | 0 | — | 0 | — | 4 | 16-24 | 37.4 | 27.0 | 6.0 |
| 1 | 7-21-64 | 1 | 0 | — | 0 | — | 1 | 16 | 35.6 | 28.0 | 4.0 |
| 6 | 7-21-64 | 3 | 0 | — | 0 | — | 3 | 30-51 | 33.5 | 31.0 | 4.0 |
| 1 | 7-28-64 | 0 | — | — | — | — | — | — | 33.9 | 32.0 | 3.0 |

* Data not available.

Limited growth studies were made on two slightly advanced postlarvae held in separate tanks at our Stuart Laboratory. All measurements listed were made from the horns to the rear edge of the carapace, along the mid-dorsal line.

Spiny lobster A was kept in a tank with continuously changing sea water and was fed a diet of dry cat food, "Purina Cat Chow" and "Kitty Krumpets." Measurements were made from the cast carapace exoskeleton after each molt. The first cast, which measured 15 mm, was produced February 8; the second on March 24, 1964, was 16 mm. On April 16 the third molt took place, and the carapace measured 17.5 mm. Molt number four occurred on May 19, and a carapace of 21.5 mm resulted. The last molt was observed on July 26. The cast carapace measured 25 mm. Lobster A is still living at the time of this report.

The carapace of spiny lobster B measured 32.5 mm at the time of the first molt in February. A second molt took place on April 27, the cast carapace measuring 38 mm. On June 9 the third molt occurred, the cast measuring 45 mm. Molt number 4 was on July 17. The carapace then measured 52 mm. This lobster was found dead on July 28, at which time the carapace length was 61 mm. Throughout the period of confinement this lobster was offered a diet of sea slugs, sea urchins, and fish but was observed to feed only on the latter.

Other studies (Crawford and DeSmidt, 1922; Smith, 1948, 1950; Smith and Marshall, 1945; Dawson and Idyll, 1951; Sutcliffe, 1957) show a longer period between, and a smaller increase after, observed molts. These previous studies were, however, made on larger, more mature animals, so our more accelerated growth is not unexpected. Lewis's findings, on sizes similar to ours, gave results more in agreement with those we obtained.

In addition to our postlaval studies several plankton samples were taken. Two phyllosoma larvae were taken in the St. Lucie Inlet on November 11, 1963. Samples taken in the Indian River near the House of Refuge on June 16 and 25, 1964, each had one first stage larva. These phyllosomes compare with the first stage of *Panulirus argus* as described by Lewis (1951).

Recent work on estuarine biology has indicated a remarkable number of marine animals that appear to be obligated to spend their juvenile stages in the protected sanctuaries of river mouths and bays. Evidence presented here supports the belief that the